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AERONAUTICAL THEORIES.

(1) *Bases Théoriques de l'Aéronautique. Aérodynamique.* By Prof. N. Joukowski. Pp. xviii + 227. (Paris: Gauthier-Villars et Cie, 1916.) Price 11 francs.

(2) *Dynamical Stability of Aeroplanes.* By Jerome C. Hunsaker, assisted by T. H. Huff, D. W. Douglas, H. K. Chow, and Capt. V. E. Clark. Pp. 78. (Smithsonian Miscellaneous Collections, lxii., 5; Hodgkins Fund.) (Washington: Smithsonian Institution, 1916.)

(3) *Air Screws: an Introduction to the Aerofoil Theory of Screw Propulsion.* By M. A. S. Riach. Pp. viii + 128. (London: Crosby Lockwood and Son, 1916.) Price 10*s.* 6*d.* net.

(4) *Aérodonétique.* Par F. W. Lanchester. Traduit de l'anglais sur la deuxième édition par le Commandant C. Benoît. (Paris: Gauthier-Villars et Cie, 1916.) Pp. xvii + 478. Price 14 francs unbound.

(1) FOR the French translation of Prof. Joukowski's work we are indebted to Dr. S. Drzewiecki. In a separate preface the latter writer emphasises the fact that the use of the principles of mathematical physics did not receive adequate attention in the early days of artificial flight, and he advocates the recognition of aerodynamics as a separate branch of theoretical science. We regret to find that whatever extraneous arguments may be and have been adduced for placing this subject on an independent footing, there is nothing, either in the translator's eloquent introduction or in the subject-matter of the book, to justify the present claim.

Dr. Drzewiecki admits the important part which the study of fluid motions has played in the development of aeronautical theories. But he fails to realise that the matter of which the book treats is hydrodynamics pure and unadulterated. There is nothing in it of a sufficiently distinct and novel character to form the nucleus of a distinct subject with such a name of its own as aerodynamics.

On the purely mathematical side, the treatment does not extend very much beyond the formulation of the equations of motion and continuity for perfect and viscous fluids, together with the pressure equation, and a somewhat diffuse treatment of the laws of vortex motion. This, together with considerations of a practical character, occupies the first five chapters. The subsequent sections contain accounts of some of the more recent attempts to solve the equations of motion in the case of cylinders and laminæ resembling the sustaining surfaces of an aeroplane. In this connection prominence is given to the theories and experiments of Profs. Kutta, S. A. Tchapliguine, and Karman, and the Aerodynamic Laboratory at Moscow is described in an appendix. It must not, however, be forgotten that there are two ways of reconciling the existence of a pressure on a moving lamina with the properties of a perfect fluid. One method is to assume that there is circulation of the fluid round the lamina. Thus, for example, a cylinder in a perfect liquid acted on by gravity tends to travel horizontally if there is cyclic motion round it. This method appears to form the basis of most of the work in Prof. Joukowski's later chapters. On the other hand, we have the theory of discontinuous motion, originated by Kirchhoff, which has now been greatly elaborated in this country by means of the Schwartz-Christoffel transformation. Of this theory Prof. Joukowski's treatment is practically *nil.*

Up to the present time very little has been done in investigating the motion of solids through *compressible* fluids. It is true that compressibility does not greatly affect the character of the motion so long as the velocities are everywhere small compared with the velocity of sound in the same medium. But this condition can scarcely be regarded as binding in the neighbourhood of a sharp-edged boundary; in fact, according to Boyle's law, the pressure would simply vanish and would not become negative at a point at which the velocity was infinite. The problems treated by Prof. Joukowski are essentially based on the hypothesis of a velocity potential satisfying Laplace's equation of continuity, and they therefore belong to the subject of hydrodynamics proper. According to the usual convention in this country, experimental and practical considerations regarding the motion of fluids are classified under the designation of *hydraulics.* It is very important that engineering students who are proposing to take up aeronautical work should be equipped with a knowledge of the necessary hydrodynamics and hydraulics, and Prof. Joukowski's lectures were probably admirably adapted to the students in his classes. But the book goes only a very little way towards covering the subject-matter contained in the English treatises on hydrodynamics of more than thirty years ago, with their chapters on sources, doublets, and images, motion in rotating cylinders in the form of lemniscates and cardioids, motions of a solid in a liquid, tides and waves, and detailed treatment of discontinuous motion in two dimensions. It is quite clear that the advanced student will find it much more helpful to turn to one of these early books for a thorough grounding in hydrodynamics than to rely on a more superficial and fragmentary treatment of the same subject, which is all that he will find in the present volume.

(2) An examination of the paper by Messrs. "Hunsaker and others" suggests that in the scientific study of aeroplane stability America is far behind Great Britain. The only part of this paper which has any claim to novelty consists in the determinations of the coefficients of stability of two aeroplanes (the Clark and Curtiss types) based on experiments with models. The methods of experimenting were identical with those used in our National Physical Laboratory, of which the details were developed by the energies of Mr. L. Bairstow.

The publication of these experimental data derives additional interest from the fact that owing to war conditions the National Physical Laboratory has been unable to issue published results of experiments with any machines other than a Blériot monoplane which was tested as an illustration of the general method before the war broke out. On the other hand, the paper deals largely with mathematical considerations, and on examination there will be found to be scarcely a single feature for which chapter and verse cannot be found in the present reviewer's "Stability in Aviation," published five years ago. It scarcely appears desirable, when so much further work remains to be done, that the resources of the Hodgkins Fund should be expended in duplicating what has previously been said and worked out in greater detail elsewhere. Furthermore, several changes that have been introduced into the treatment are open to serious objections. We all regret the discrepancy between the coordinate axes of the National Physical Laboratory papers and those used in the mathematical theories; unfortunately, as the result of mutual discussion, it is evidently impossible to break the continuity of the Teddington investigations. But there is no justification for extending this lack of uniformity to an entirely new set of investigations started in America. The main reason for objecting to the system in question is that the notation is unfamiliar to English students, all of whom have acquired their knowledge of applied mathematics, in the first instance, from the study of two-dimensional problems, and afterwards extended it to three-dimensional space. This objection applies with special force to the problem of longitudinal stability, which is essentially two-dimensional. But Messrs. "Hunsaker and others" make further changes which are not only very confusing, but out of accord with the usage of both our mathematicians and our physicists. The most objectionable feature is the use of the letter D in two entirely different meanings in the same equation with only a suffix to distinguish them. The writers would have done well to study a little more carefully the long alphabet at the end of "Stability in Aviation."

The exclusive reference to Mr. Bairstow in connection with the splitting up of the two biquadratics is open to the objection that it would be quite impossible for anyone without exceptional mathematical ability and power of insight to deduce the formulæ in question by any method of factorisation or numerical substitution indicated in the advisory committee's National Physical Report, Paper No. 77, and even verification by long multiplication is none too easy, whereas the proof in "Stability in Aviation" is perfectly straightforward and simple.

The omission of references to methods of *successive* approximation is again unfortunate when the authors come to describe the character of the lateral motions. Why, for example, is one root of the biquadratic said to represent a "spiral dive" and another pair to represent a "Dutch roll"? These things can be found partially explained in "Stability in Aviation" (although the late Prof. Harper worked the subject out in greater detail in a paper he never published) and also in Mr. Bairstow's National Physical Laboratory researches, but a reader of this paper would think that the difference in the periods and logarithmic increments or decrements was the only essential distinction.

A still worse feature of the whole investigation is that while acknowledging the influences of circular motion on stability, the writers completely ignore the "Harper effect." The present reviewer hopes that a fitting recognition may be given to the work of his former assistant and colleague, the late Lieut. E. H. Harper, M.A. (professor of mathematical physics in University College, Cork, and recently killed in action), by thus associating his name with his independent discovery that stability, both longitudinal and lateral, is greatly affected by even small changes in the inclination of the line of flight to the horizon. An aeroplane fatality has recently been reported which was clearly attributable to this cause.

It was no intention of the author of "Stability in Aviation" to extend his criticisms to statements, conclusions, and expressions of opinion which fall within the province of the physicist or engineer rather than within that of the mathematician. But apart from specific references to the two machines which formed the subject of the experiments, the similarity between the present treatment and that of the Science Monograph obtrudes itself on one's notice in the most unexpected quarters. It will be most interesting to learn whether Mr. Hunsaker fares better than did the present writer in appealing to practical men to study stability with models rather than to rely on experiments in the open air. He states (p. 5) that he actually "knew a pilot" who nearly lost his life by trying a spiral dive in the air! But when "Stability in Aviation" was in the press fatalities occurred daily, and killing off the pilots of unsafe machines was the only method that the practical man would have anything to do with. To invoke the assistance of a mathematician would have been an idea too terrible for words, and as for compensating him for his loss of time over the work, this might have cost 100*l.*, which would have been a preposterous waste of money when the same thing could be done by smashing up ten machines costing 1000*l.* each.

Mr. Hunsaker claims that laboratory experiments and calculations are superior to tests made in the open air, and remarks that "weather conditions, motor troubles, personal peculiarities of pilots, etc., tend to add to the complexity of an otherwise very simple problem." But exactly the same considerations were invoked in 1910 by the opponents of theoretical and physical methods as proving that the latter methods were practically useless. The large number of mathematical investigations (some of them in progress) that were bundled into the collection of "problems" at the end of "Stability in Aviation" will give some idea of the amount of work which, as the result of this opposition, was suspended on the ground that no useful purpose would be served by its continuance.

(3) It was in 1882 that Drzewiecki first propounded a theory of propeller action based on the supposition that if the length of a screw-blade be split up into small elements the fluid motion in the neighbourhood of any element may be regarded as two-dimensional, and independent of the differences of shape of the neighbouring elements, so that the effect is the same as if the element in question formed a section of a cylinder moving through the same medium with uniform velocity. Reference to the same method will be found in Lanchester's "Aerodynamics." But at the time of Drzewiecki's first papers the principal screws occurring in engineering practice were the propellers of ships, and these are sometimes broad enough to account for considerable divergences between theory and experiment. Parenthetically, too, it will be seen from Sir G. Greenhill's "Dynamics of Mechanical Flight" that Newton's "sine squared" law of resistance still figures largely in some of the well-known theories of propeller action.

The assumption under consideration is the same as that made by the present writer in connection with lateral stability under the title, "Further Hypotheses regarding Narrow Planes." Mr. Riach's figures of the blades of modern air screws suggest that these are sufficiently narrow to justify an investigation of their efficiency based on this admittedly rough-and-ready, approximate method.

It is the object of the present work to develop this method of investigation to its ultimate logical conclusions. This is a perfectly definite piece of purely mathematical work involving nothing harder than writing down integrals, except that the solid geometry of the screw and the different kinds of pitch associated with it is rather puzzling. It would thus be easy for anyone to work out all the results for himself, and it is doubtful whether it is worth paying ten shillings to have this done. But even if nothing else could be said in favour of the book, it is a great gain to have the formulæ ready worked out and displayed in print. And, after all, there is a great deal to be said on the subject, and there are many minor details which not everyone would think of working out. The various forms of blade proposed and described as the "efficiency curve," "rational," "normal," and "constructional limit" outlines are interesting.

Mr. Riach is under no misapprehensions as to what his investigation does and does not prove. If the fundamental assumptions are admitted, the rest follows as a logical consequence. Divergences between theoretical and experimental results will depend on the extent to which the actual stream-lines of the medium differ from those based on the two-dimensional or aerofoil hypothesis. The author finds that in many cases a fairly close agreement has been found between theory and practice, but, as he freely admits, there are cases in which the differences may be considerable. It is important to bear these facts in mind, because there is a certain type of individual, unfortunately very common, who cannot, or will not, appreciate the value of an investigation conducted in this spirit, and we can only hope that Mr. Riach will not find himself dragged into a hornet's nest of controversy by cranks and faddists. There is nothing that retards progress and wastes time so much as the irrelevant "discussions" which are so often started on a perfectly straightforward piece of work. What is now required is further comparison of theory with experiment.

The book also contains chapters dealing with the stresses in propeller-blades, their design and construction, and other similar matters. It would be well, however, to point out that in working with a theory which is at best an approximation, it would be sheer waste of time to worry about evaluating complicated integrals, as a process of summation over a finite number of elements would be sufficiently accurate. At the same time, many of the integrals are comparatively simple, and some of them can be simplified by a trigonometrical transformation to an angular co-ordinate the geometrical meaning of which is obvious from the figures.

(4) Mr. Lanchester's books are too widely known to require further comment, and Commandant Benoît has adhered fairly rigorously to the original text in his translation, not even venturing to insert a preface of his own in addition to that dated May, 1908, by the author. Probably this was the best plan, for everything has now changed so greatly that it would be impossible to bring a book up to date nearly nine years after publication.

G. H. BRYAN.

MILK AND THE PUBLIC HEALTH.

Milk and its Hygienic Relations. By Dr. Janet E. Lane-Claypon. Pp. viii + 348. (London: Longmans, Green and Co., 1916.) Price 7*s.* 6*d.* net.

THIS book is published under the auspices of the Medical Research Committee, which is charged with the administration of the Research Fund which has become available under the provisions of the National Insurance Act for the advancement of medical knowledge by research. Milk has very important relations to the public health, but the study of milk has been conducted by workers in chemistry, physiology, bacteriology, agricultural science, and clinical medicine, and the results of their researches have appeared in journals devoted to all these branches of science. With the view of collating this mass of literature, the Medical Research Committee invited Dr. Janet Lane-Claypon to assist them in collecting the available scientific evidence upon the hygienic relations of milk from all the best sources of information, however widely scattered, and the present volume is the outcome of her labours. Not only has a large mass of literature been abstracted, but critical summaries are provided in addition, and extensive bibliographies are appended to the subjects dealt with which will be very valuable to future workers.

The general composition of milk and its organic and inorganic constituents are summarised in chaps. ii., iii., and iv. The "biological" proper-